International Journal of Scientific Research and Engineering Development-– Volume 9 Issue 3, May-June 2026
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Literature Study on Passive Cooling Towards Intermediate Houses in Malaysia

Ananthan Valitherm
*(Department of Surveying, Universiti Tunku Abdul Rahman, Malaysia
Email: ananthan@utar.edu.my

--************************----------------------------------

Abstract:

Across the world, people are more prompt to the application of mechanical cooling system for indoor comfort. In the past twenty years, developing countries have encountered significant critical period in the depletion of natural resources because of the large amount of heat energy from buildings. The high consumption of energy by human has significantly affected the climate ultimately be the cause of climate change and depletion of the ozone layer. The aim of the study is to introduce the application of passive cooling systems to maximize the indoor comfort while keep the consumption of energy to minimum by building occupants. Thus, this present paper reviews and accesses on the several passive cooling strategies and their benefits in delivering comfort to indoor building occupants.

Keywords — **Passive Cooling, Thermal Comfort, Intermediate Houses,**

--************************----------------------------------

I. INTRODUCTION

In this developing world, majority of developing countries are experiencing rapid growing population and urbanization over the years (Kubota et al., 2011). According to Santamouris (2005), construction sector is one of the major contributors to the economy. With the rapid growing population, this has increased human's need for housings. This brings to a point where the energy consumptions by indoor occupants have increased. Kamal (2012) highlighted that, developing countries have experienced energy crisis that due to occupant comfort needs and this has led to high energy consumption in buildings. In Malaysia, the growing of population has increased drastically from 10.4 million to 22.2 million in the year 1970 to 2000 and this brings to the high energy demand of five times greater in the last two decades (Kubota et al., 2011). In the recent survey found by Suruhanjaya Tenaga (2017), building sector has occupied 40% of energy consumption in Malaysia where industry sector has taken up 32% and transportation sector 28%.

Following the development of world economy, science and technology, the standard of life and requirement of quality are improving. Humans have strong desire in demanding better quality life in terms of their thermal comfort, habits, design, and life style. Comfort of human is becoming one of the essential matters in worldwide. Rajapaksha, Nagai and Okumiya (2003) revealed that high temperature of indoor is commonly happen in warm and humid region because of the solar can easily gain access into interior of the building. This problem commonly happens in Malaysia's terraced houses which they are built repetitively in a row. Based on the study of previous researchers, building has occupied 50% of energy for user's thermal comfort (Hassan et al., 2014). Hassan et al., (2014) stated with this high consumption of energy by housing occupants for their indoor comfort has resulted environmental issues in recent years. In the study of Kamal (2012), the over consumption of energy has caused acid rain, smog formation, and climate changes.

Therefore, with the awareness of high temperature and high humidity conditions in Malaysia, it is recommended to utilize natural ventilation such as passive cooling as an appropriate cooling method to prevent indoor overheating and climate modifications (Rajapaksha, Nagai and Okumiya, 2003).

II. PROBLEM STATEMENT

The problem statement highlights that the increasing dependence on mechanical cooling systems, particularly air conditioning, has resulted in excessive energy consumption and negative impacts on the environment. In tropical countries such as Malaysia and other Southeast Asian nations, the hot and humid climate increases the need for indoor thermal comfort, leading occupants to rely heavily on air-conditioning systems (Maarof & Jones, n.d.). Research shows that households using air-conditioners consume 1.5 times more energy than households without them, with an average usage of six hours daily (Kubota et al., 2011). Furthermore, the widespread installation of air-conditioning units worldwide demonstrates the growing dependence on mechanical cooling systems (IIR, 2002). Consequently, traditional natural cooling techniques and passive design strategies are increasingly neglected, contributing to higher energy consumption and environmental degradation (Samuel, Nagendra & Maiya, 2013; Kamal, 2012)

III. RESEARCH AIM

The aim of this research is to reduce the usage of mechanical cooling system by studying the strategies to implement passive cooling and optimize the use of passive cooling towards intermediate houses in Malaysia.

IV. PASSIVE COOLING DESIGN STRATEGIES

Passive cooling design refers to architectural and environmental strategies that utilize natural resources such as wind, shading, vegetation, and material properties to achieve indoor thermal comfort without relying heavily on mechanical cooling systems like air-conditioning (Altan et al., 2016). In tropical countries such as Malaysia, where the climate is hot and humid throughout the year, passive cooling is essential because buildings are highly exposed to solar radiation, high temperatures, and humidity (Kamal, 2012). Excessive use of mechanical cooling systems not only increases electricity consumption but also contributes to environmental degradation and higher cooling costs (Roslan et al., 2016). Therefore, passive cooling strategies are increasingly recognized as sustainable approaches to improve indoor comfort, reduce heat gain, lower energy consumption, and enhance indoor air quality.

1. Shading Devices

Shading devices are one of the most practical and effective passive cooling strategies because they prevent direct solar radiation from penetrating into the building envelope (Ahmadkhani, 2011). Solar heat gain mainly occurs through roofs, walls, and openings such as windows and doors. By blocking sunlight before it enters the interior space, shading devices help maintain lower indoor temperatures and reduce the need for air-conditioning systems.

Research by Wahab and Ismail (n.d.) showed that appropriate shading devices can reduce cooling costs by up to 40%, while Kumar, Garg and Kaushik (2005) found that shaded buildings can lower indoor temperatures by approximately 2.5°C to 4.5°C compared to buildings without shading. This demonstrates that shading devices significantly improve thermal performance and energy efficiency.

Shading devices can be categorized into external and internal shading systems. External shading devices are more efficient because they intercept solar radiation before it reaches the building interior (Ahmadkhani, 2011). Examples include overhangs, louvers, awnings, and canopies. Horizontal shading devices are considered more effective than vertical shading systems in tropical climates because they better block high-angle sunlight (Ahmadkhani, 2011). However, their effectiveness depends greatly on building orientation, solar angle, and climatic conditions (Subramanian & Divya, 2016).

Louvers are widely used because they can provide shading while still allowing airflow and daylight penetration. Taleb (2014) explained that louvers tilted at 45 degrees are particularly suitable for hot and humid climates because they block solar radiation and rain while permitting natural ventilation. Louvers also help reduce radiant heat when the sun is at a high angle but continue to provide sufficient daylight indoors. In addition, combining shading devices with tinted or reflective glass can further improve cooling efficiency by reducing solar heat penetration (Chenvidyakarn, 2007).

Overhangs are another common shading strategy. They are particularly effective for south-facing windows where solar angles are high (Kamal, 2012). According to Florides et al. (2002), larger overhang spans increase shading effectiveness and reduce annual cooling loads. Studies revealed that installing overhangs with a span of 1.5 meters can reduce yearly cooling loads by approximately 7%. Therefore, shading devices not only improve occupant comfort but also reduce energy consumption and operational costs.

2. *Shading by Trees and Vegetation*

Vegetation and landscaping are natural passive cooling elements that moderate surrounding temperatures and reduce heat gain around buildings (Kamal, 2012). Trees, shrubs, climbers, pergolas, and ground vegetation provide shade to roofs, walls, and windows while reducing the amount of direct solar radiation reaching the building envelope (Chenvidyakarn, 2007).

One important cooling mechanism provided by vegetation is evapotranspiration, where plants release water vapor into the atmosphere and cool the surrounding environment. Ahmadkhani (2011), Kamal (2012), and Magaji and Sa'adiya Ilyasu (2017) found that vegetation can reduce surrounding temperatures by approximately 5°C. This cooling effect significantly improves outdoor microclimates and indirectly enhances indoor thermal comfort. Research on Traditional Malay Houses also demonstrated that surrounding vegetation effectively lowers indoor temperatures and creates a cooler living environment (Wahab & Ismail, n.d.). In addition, shaded exterior walls can be 5°C to 15°C cooler compared to unshaded walls (Chenvidyakarn, 2007). This reduction minimizes heat transfer into the building interior.

The effectiveness of vegetation depends on factors such as plant type, orientation, density, and growth characteristics (Ahmadkhani, 2011). Large trees provide broad shading coverage, while climbing plants such as English ivy and jasmine are suitable for terrace houses with limited outdoor space. Ground vegetation also reduces reflected solar radiation from paved surfaces and prevents heat accumulation around buildings (Chenvidyakarn, 2007). When integrated with other passive cooling methods such as shading devices and insulation, vegetation can significantly improve building thermal performance.

3. *Choice of Materials*

Building materials strongly influence the amount of heat absorbed, stored, and transferred into indoor spaces (Chenvidyakarn, 2007). Appropriate material selection is therefore essential for reducing heat gain and improving thermal comfort in tropical climates. Roof systems are especially important because roofs receive the highest solar exposure. Studies suggest that roofs constructed with multiple layers, including insulation, reflective materials, and ventilation gaps, can effectively minimize heat transfer into buildings (Wahab & Ismail, n.d.). Reflective materials such as aluminium foil reduce radiant heat absorption, while insulation materials like glass fibre and foam slow heat conduction (Chenvidyakarn, 2007). Ventilation gaps between roof layers help remove trapped hot air and improve cooling efficiency.

Wall materials also influence thermal performance. Materials with high reflectivity, such as white plaster, reflect more solar radiation than darker or denser materials like concrete blocks. White plaster can reflect up to 80% of heat, while concrete blocks reflect only around 23–30% (Panulin, n.d.). In hot and humid climates, lightweight materials are generally preferred because they cool down more rapidly at night and release less stored heat into indoor spaces (Bodach, Lang & Hamhaber, 2014). However, Chenvidyakarn (2007) explained that thermal mass materials may still be useful during daytime because they delay heat transfer and stabilize indoor temperatures. Thus, material selection should consider climatic conditions, occupancy patterns, and building functions.

4. Choice of Colour

Colour selection significantly affects heat absorption and thermal efficiency of building envelopes (Han, Lu & Yang, 2009). Dark-coloured surfaces absorb more solar radiation, while light-coloured surfaces reflect more heat and maintain cooler surface temperatures. Research by Wahab and Ismail (n.d.) showed that dark surfaces can absorb between 70% and 90% of solar heat, increasing indoor temperatures and cooling loads. In contrast, light-coloured and smooth surfaces reflect solar radiation more effectively, reducing heat transfer into buildings (Chenvidyakarn, 2007).

Han, Lu and Yang (2009) conducted studies comparing black and white painted surfaces and found that black surfaces absorbed significantly more heat than white surfaces. Buildings with high absorptivity surfaces require greater mechanical cooling to maintain thermal comfort. Therefore, the use of light-coloured roofing and wall finishes is recommended for tropical climates because it lowers indoor temperatures and reduces energy demand (Ahmed et al., 2014).

5. Building Orientation

Building orientation determines the amount of solar radiation and natural airflow received by a building (Thomas & Garnham, 2007). Proper orientation is crucial in hot and humid climates because it directly influences indoor thermal comfort, natural ventilation, and energy efficiency. Chenvidyakarn (2007) emphasized that traditional tropical houses often adopt spread-out layouts where longer building facades face prevailing winds to maximize ventilation. Windward orientations intercept cool breezes, while minimizing exposure to intense solar radiation from east and west directions.

Research indicates that east and west facades receive the greatest solar exposure and therefore should minimize large openings or windows (La Roche et al., 2001). Spaces with high occupancy such as living rooms should ideally face north or other cooler orientations, while less occupied spaces such as storerooms or washrooms can be placed on hotter facades to act as thermal buffers (South African National Standard, 2011). Proper orientation reduces heat gain, improves daylighting, enhances airflow, and decreases dependence on artificial cooling and lighting systems.

6. Building Form and Natural Ventilation

Building form influences airflow patterns, heat exposure, and ventilation performance (Daghigh, 2015). Compact building forms reduce the amount of exposed building envelope and therefore minimize solar heat penetration (Hassan, Lee & Oh, 2016). Features such as undulating roofs can create self-shading effects and improve thermal performance.

Natural ventilation is one of the most important passive cooling strategies in tropical architecture because it improves airflow, indoor air quality, and occupant comfort without energy consumption. Studies found that natural ventilation can reduce electricity costs by up to 40% (Ahmed et al., 2014).

Two major natural ventilation strategies are cross ventilation and stack ventilation. Cross ventilation occurs when air enters through openings on one side of a building and exits through opposite openings, creating continuous airflow (Ahmed et al., 2014). This strategy removes indoor heat, introduces fresh outdoor air, and improves indoor air quality. Effective cross ventilation depends on the size, placement, and orientation of openings (Altan et al., 2016). Buildings in tropical climates should orient longer facades along the north-south direction to maximize prevailing winds (Aflaki, Mahyuddin & Mahmoud Awad, 2012).

Stack ventilation works based on thermal buoyancy, where warm air rises and exits through higher openings while cooler air enters through lower openings (Ismail & Rahman, 2012). This strategy is particularly useful for terrace houses or buildings with limited side openings. The effectiveness of stack ventilation depends on the height difference between openings and the temperature difference between indoor and outdoor air (Wahab & Ismail, n.d.). Both ventilation strategies improve thermal comfort and reduce dependence on mechanical systems.

7. Courtyard Design

Courtyards are enclosed or semi-enclosed open spaces integrated within buildings to improve ventilation, shading, and thermal comfort (Younis, 2016). Courtyards have been widely used in Traditional Malay Houses and many vernacular architectural styles because they effectively cool indoor environments and support social activities.

Courtyards improve airflow by creating pressure differences and encouraging natural ventilation throughout surrounding spaces (Rajapaksha, Nagai & Okumiya, 2002). Buildings with courtyards generally achieve better ventilation and thermal comfort compared to mechanically ventilated buildings. Courtyards also reduce energy consumption by minimizing the need for air-conditioning (Akande, 2010).The performance of courtyards depends on orientation, proportions, wall height, and integration of natural elements. Longer courtyard axes facing north-south are believed to provide better thermal performance because they optimize shading and airflow (Almhafdy et al., 2013). Higher courtyard walls can reduce hot air penetration and improve cooling effects (Bulus, 2016).

Vegetation and water features inside courtyards further enhance thermal performance. Trees provide shade and absorb solar radiation, while water ponds increase evaporative cooling and reduce surrounding temperatures (Jamei et al., 2016). Courtyards therefore create a comfortable microclimate that improves indoor environmental quality while promoting sustainable architectural design. Overall, passive cooling strategies demonstrate that architectural design, natural ventilation, landscaping, material selection, and environmental planning can significantly reduce building energy consumption and improve thermal comfort. These strategies are particularly important in tropical climates because they provide sustainable alternatives to excessive reliance on mechanical cooling systems.

V. CONCLUSION

In conclusion, the literature review demonstrates that passive cooling strategies are highly effective in improving indoor thermal comfort and reducing dependence on mechanical cooling systems in tropical climates such as Malaysia. The reviewed studies consistently highlighted those strategies including shading devices, vegetation and landscaping, appropriate material selection, light-coloured building surfaces, proper building orientation, natural ventilation, and courtyard design contribute significantly to minimizing heat gain, enhancing airflow, and lowering indoor temperatures. Shading devices such as overhangs and louvers were found to effectively block solar radiation and reduce cooling loads, while vegetation and trees provide additional cooling through shading and evapotranspiration processes.

Furthermore, the use of reflective and insulated building materials, together with light-coloured surfaces, helps reduce heat absorption and improve thermal efficiency of buildings. Proper building orientation and compact building forms were also identified as important factors in maximizing natural ventilation and minimizing direct solar exposure. Among the passive cooling approaches, natural ventilation strategies such as cross ventilation and stack ventilation were emphasized as essential methods to improve indoor air quality and thermal comfort while reducing electricity consumption. In addition, courtyard design was recognized as an effective traditional passive cooling strategy that enhances ventilation, creates shaded microclimates, and improves environmental performance within residential buildings. Overall, the literature review confirms that integrating multiple passive cooling strategies can provide sustainable, energy-efficient, and environmentally friendly solutions for residential buildings, particularly intermediate houses in Malaysia.

REFERENCES

[1] Abdul Rahman, A.M., Khalid, H.L. and Yusup, Y., 2011. Optimizing Wind Power for Energy Efficient Building Design in Tropical Hot-humid Climate of Malaysia. Journal of Sustainable Development, 4(2), pp.217–224.

[2] Abidin, N.Z., Yusof, N. and Othman, A.A.E., 2013. Enablers and challenges of a sustainable housing industry in Malaysia. Construction Innovation, 13(1), pp.10–25.

[3] Aflaki, A., Mahyuddin, N. and Mahmoud Awad, Z.A.-C., 2012. Study on Efficiency of Passive Cooling Strategies on Thermal Comfort Attainment within Tropical Climate. Towards Comprehensive and Sustainable Built Environment, (January), pp.133–143.

[4] Ahmad, SS & Szokolay, SV 2007, The performance of a partially air conditioned apartment building in Kuala Lumpur. in Sun, Wind and Architecture - The Proceedings of the 24th International Conference on Passive and Low Energy Architecture, PLEA 2007. pp. 225-231, 24th International conference on Passive and Low Energy Architecture, PLEA 2007, Singapore, Singapore, 11/22/07.

[5] Ahmadkhani, B., 2011. Shading : Passive Cooling and Energy Conservation in Buildings. International Journal on 'Technical and Physical Problems of Engineering' (IJTPE), 3(9), pp.72–79.

[6] Ahmed, A.S.F., Khan, K.M.M.K., Maung Than Oo, A.A. and Rasul, R.M.G., 2014. Selection of suitable passive cooling strategy for a subtropical climate. International Journal of Mechanical and Materials Engineering, 9(1), pp.1–11.

[7] AI, I., Shari, Z. and Jafaar, M.F., 2015. Occupants' Utilization of Natural Ventilation: A Study of Selected Terrace House Designs in Hot-humid Climate. International Journal of Built Environment and Sustainability, 2(2), pp.62–74.

[8] Ajayi, V.O., 2017. Primary Sources of Data and Secondary Sources of Data. Advance Statistical Methods in Education, pp.1–5.

[9] Akande, O.K., 2010. Passive design strategies for residential buildings in a hot dry climate in Nigeria. WIT Transactions on Ecology and the Environment, 128, pp.61–71.

[10] Albers, M.J., 2017. Quantitative data analysis-in the graduate curriculum. Journal of Technical Writing and Communication, 47(2), pp.215–233.

[11]

[12] Al Horr, Y., Arif, M., Kaushik, A., Mazroei, A., Katafygiotou, M. and Elsarrag, E., 2016. Occupant productivity and office indoor environment quality: A review of the literature. Building and Environment, 105(16), pp.369–389.

[13] Ali-Toudert, F. and Mayer, H., 2006. Numerical study on the effects of aspect ratio and orientation of an urban street canyon on outdoor thermal comfort in hot and dry climate. Building and Environment, 41(2), pp.94–108.

[14] Almhafdy, A., Ibrahim, N., Ahmad, S.S. and Yahya, J., 2013. Courtyard Design Variants and Microclimate Performance. Procedia Social and Behavioral Sciences, 101, pp.170–180.

[15] Altan, H., Hajibandeh, M., Aoul, K.A.T. and Deep, A., 2016. Passive Design. (June), pp.209–236.

[16] Anderson, J.D., 2006. Qualitative and Quantitative Researchs. Imperial COE.

[17] Anderson, L.M., Mulligan, B.E. and Goodman, L.S., 1984. Effects of Vegetation on Human Response To Sound. J. Arboriculture, 10(2), pp.45–49.

[18] Anon 2007. Renewable for Heating and Cooling. International Energy Agency.

[19] Anon 2014. CoolVent. [online] Available at: <http://coolvent.mit.edu/intro-to-natural-ventilation/> [Accessed 20 Feb. 2019].

[20] Anon 2016. JUBM and Langdon Seah Construction Cost Handbook, Malaysia.

[21] Anon 2019. Malaysia Property Reviews. [online] Available at: <https://www.malaysiapropertyreviews.com/gamuda-gardens/lavena/> [Accessed 14 Mar. 2019].

[22] Aziz, H.A., 2014. The Effect of Thermal Comfort on Workers' Productivity in an Air-Conditioned Environment. pp.1–44.

[23] Azzmi, N.M. and Jamaludin, N., 2014. A Review of Heat Transfer in Terraced Houses of Tropical Climate. Environment, Energy and Earth Sciences, pp.1–6.

[24] Bagneid, A.M.R., 2006. The Creation of a Courtyard Microclimate Thermal Model for the Analysis of Courtyard Houses. Cairo University.

[25] Bansal, N.K., Garg, S.N. and Kothari, S., 1992. Effect of Exterior Surface Colour on the Thermal Performance of Buildings. Building and Environment, 27(1), pp.31–37.

[26] Barbhuiya, S. and Barbhuiya, S., 2013. Thermal comfort and energy consumption in a UK educational building. Building and Environment, 68, pp.1–11.

[27] Bodach, S., Lang, W. and Hamhaber, J., 2014. Climate responsive building design strategies of vernacular architecture in Nepal. Energy and Buildings, 81, pp.227–242.

[28] Bulus, M., 2016. Evaluation of Courtyard Usage and Its Design Requirement in Residential Buildings in Nigerian Hot Dry Climate. International Journal of African Society Cultures and Traditions, 4(4), pp.1–12.

[29] Canlas, I.P., 2016. Color, Temperature and Heat: Exploring University Students Mental Thoughts. Universal Journal of Educational Research, 4(1), pp.72–75.

[30] Carslaw, N., 2007. A new detailed chemical model for indoor air pollution. Atmospheric Environment, 41(6), pp.1164–1179.

[31] CETDEM (Centre for Environment, Technology & Development, Malaysia) (2006). A CETDEM study on energy efficiency: working with the community on energy efficiency at household level in Petaling Jaya.

[32] Chan, H.Y., Riffat, S.B. and Zhu, J., 2010. Review of passive solar heating and cooling technologies. Renewable and Sustainable Energy Reviews, 14(2), pp.781–789.

[33] Chenvidyakarn, T., 2007. Passive Design for Thermal Comfort in Hot Humid Climates. Journal of Architectural/Planning Research and Studies, 5(1), pp.1–28.

[34] Clements-Croome, D., 2015. Creative and productive workplaces: a review. Intelligent Buildings International, 7(4), pp.164–183.

[35] Daghigh, R., 2015. Assessing the thermal comfort and ventilation in Malaysia and the surrounding regions. Renewable and Sustainable Energy Reviews, 48, pp.681–691.

[36] Das, N., 2006. Courtyards Houses of Kolkata : Bioclimatic , Typological and Socio-Cultural Study. Birla Institute of Technology.

[37] Dawson, D.C., 2002. Practical Research Methods.

[38] Dekay, M. and Brown, G.Z., 2001. SUN, WIND & LIGHT: Architectural Design Strategies. 2nd ed. Society of Building Science Educators. New York: John Wiley and Sons Inc.

[39] De Salis, M.H.F., Oldham, D.J. and Sharples, S., 2002. Noise control strategies for naturally ventilated buildings. Building and Environment, 37(5), pp.471–484.

[40] Diem, K.G., n.d. Choosing Appropriate Research Methods to Evaluate Educational Programs. Rutgers Cooperative Extension.

[41] Ealiwa, M.A., Taki, A.H., Howarth, A.T. and Seden, M.R., 2001. Investigation into thermal comfort in the summer season of Ghadames, Libya. Building and Environment, 36(2), pp.231–237.

[42] Edwards, B., Sibley, M., Hakmi, M. and Land, P., 2006. Courtyard Housing: Past, Present and Future. First ed. Taylor & Francis.
[43] Elfil, M. and Negida, A., 2017. Sampling methods in Clinical Research; an Educational Review. Educational, 5(1).
[44] Epstein, Y. and Moran, D.S., 2006. Thermal Comfort and the Heat Stress Indices. Industrial Health, 44(3), pp.388–398.
[45] Florides, G.A., Tassou, S.A., Kalogirou, S.A. and Wrobel, L.C., 2002. Measures used to lower building energy consumption and their cost effectiveness. Applied Energy, 73(3), pp.299–328.
[46] Foddy, W., 1993. Constructing Questions for Interviews and Questionnaires. Constructing Questions for Interviews and Questionnaires. The Press Syndicate Of The University Of Cambridge.
[47] Foong, L.W., Thang, K.F. and Chin, W.M., 2015. Application of Active Noise Control for Air-Conditioning System. Proceedings of the International Conference on Electrical and Electronic Telecommunication Engineering, and Mechatronics, pp.14–21.
[48] Ghaffarianhoseini, A., Berardi, U. and Ghaffarianhoseini, A., 2015. Thermal performance characteristics of unshaded courtyards in hot and humid climates. Building and Environment, 87, pp.154–168.
[49] Gogtay, N.J. and Thatte, U.M., 2017. Principles of correlation analysis. Journal of Association of Physicians of India, 65, pp.78–81.
[50] Haase, M. and Amato, A., 2009. An investigation of the potential for natural ventilation and building orientation to achieve thermal comfort in warm and humid climates. Solar Energy, 83(3), pp.389–399.
[51] Hamzah, N.A., Anua, S.M. and Kok, E.J., 2017. Indoor Air Quality and Symptoms of Sick Building Syndrome in Two Selected Building (New versus Old). Journal of Occupational Safety and Health, 14(2), pp.7–14.
[52] Han, J., Lu, L. and Yang, H., 2009. Investigation on the thermal performance of different lightweight roofing structures and its effect on space cooling load. Applied Thermal Engineering, 29, pp.2491–2499.
[53]
[54] Hasehzadeh Haseh, R., Khakzand, M. and Ojaghlou, M., 2018. Optimal Thermal Characteristics of the Courtyard in the Hot and Arid Climate of Isfahan. Buildings, 8(12), p.166.
[55] Hassan, A.M., Lee, H. and Oh, S., 2016. Challenges of passive cooling techniques in buildings: A critical review for identifying the resilient technique. Jurnal Teknologi, 78(6), pp.149–162.
[56] Hassan, J.S., Zin, R.M., Majid, M.Z.A., Balubaid, S. and Hainin, M.R., 2014. Building Energy Consumption in Malaysia: An Overview. Jurnal Teknologi, 70(7), pp.33–38.
[57] Heerwagen, J., 2000. Green buildings, organizational success and occupant productivity. Building Research & Information, 28(5–6), pp.353–367.
[58] Hoof, J. van, Mazej, M. and Hensen, J.L.., 2010. Thermal comfort: research and practice. Frontiers in Bioscience, 15(2), pp.765–788.
[59] Huizenga, C., Abbaszadeh, S., Zagreus, L. and Arens, E., 2006. Air quality and thermal comfort in office buildings: Results of a large indoor environmental quality survey. Proceeding of Healthy Buildings 2006, 3, pp.399–397.
[60] International Institute of Refrigeration. 2002. Industry as a partner for sustainable development – refrigeration,. Report Published by, Paris, France
[61] Ismail, M. and Rahman, A., 2012. Stack Ventilation Strategies In Architectural Context: A Brief Review Of Historical Development, Current Trends And Future Possibilities. International Journal of Research and Reviews in Applied Sciences, 11(2), pp.291–301.
[62] Iwaro, J. and Mwasha, A., 2010. A review of building energy regulation and policy for energy conservation in developing countries. Energy Policy, 38(12), pp.7744–7755.
[63] Jamaludin, N., Mohammed, N.I., Khamidi, M.F. and Wahab, S.N.A., 2015. Thermal Comfort of Residential Building in Malaysia at Different Micro-climates. Procedia Social and Behavioral Sciences, 170, pp.613–623.
[64] Jamei, E., Rajagopalan, P., Seyedmahmoudian, M. and Jamei, Y., 2016. Review on the impact of urban geometry and pedestrian level greening on outdoor thermal comfort. Renewable and Sustainable Energy Reviews, 54, pp.1002–1017.
[65] Joshi, S., 2008. The sick building syndrome. Indian Journal of Occupational and Environmental Medicine, 12(2), pp.61–64.
[66]
[67] Kamal, M.A., 2012. An Overview of Passive Cooling Techniques in Buildings: Design Concepts and Architectural Interventions. Civil Engineering & Architecture, 55(1), pp.84–97.
[68] Kampa, M. and Castanas, E., 2008. Human health effects of air pollution. Environmental Pollution, 151, pp.362–367.
[69] Kharrufa, S.N. and Adil, Y., 2012. Upgrading the building envelope to reduce cooling loads. Energy and Buildings, 55, pp.389–396.
[70] Kothari, C., 2004. Research Mathodology : Methods and Techniques. New Age International (P) Ltd.
[71] Kumar, R., Aggarwal, R.K., Gupta, D. and Sharma, J.D., 2013. Carbon Emissions from Air-Conditioning. American Journal of Engineering Research (AJER), 2(4), pp.72–74.
[72] Kumar, R., Garg, S.N. and Kaushik, S.C., 2005. Performance evaluation of multi-passive solar applications of a non air-conditioned building. International Journal Environmental Technology and Management, 5(1), pp.60–75.
[73] La Roche, P., Quiros, C., Bravo, G., Gonzalez, E. and Machado, M., 2001. Keeping Cool Principles to Avoid Overheating in Buildings. Passive and Low Energy Architecture International. Research, Consulting and Communications (RC&C).
[74] Leung, T.M. and Chau, C.K., 2013. A Review on Barriers, Policies and Governance for Green Buildings and Sustainable Properties. Urban Density & Sustainability, pp.1–8.
[75] Ma, P. and Guo, N., 2015. Modeling of Thermal Mass in a Small Commercial Building and Potential Improvement by Applying TABS. American Journal of Mechanical Engineering, 3(2), pp.55–62.
[76] Magaji, M. and Sa'adiya Ilyasu, M., 2017. Analysing the performance of passive cooling system in Buildings: designing natural solution to summer cooling loads and Architectural Interventions. American Journal of Engineering Research (AJER), 6(10), pp.272–280.
[77] Manu, S., Rawal, R., Brager, G. and Patel, C., 2016. Opportunities and Challenges in Monitoring the Thermal Performance of Passive Buildings in India. ACEEE Summer Study on Energy Efficiency in Buildings, pp.1–12.
[78] Markus, B., 2016. A Review on Courtyard Design Criteria in Different Climatic Zones. African Research Review, 10(5), pp.181–192.
[79]
[80] Meir, I.A., Pearlmutter, D. and Etzion, Y., 1995. On the microclimatic behavior of two semi-enclosed attached courtyards in a hot dry region. Building and Environment, 30(4), pp.563–572.
[81] Miller, N.G., Pogue, D., Gough, Q.D. and Davis, S.M., 2009. Green Buildings and Productivity. Josre, 1(1), pp.65–89.
[82] Noordzij, M., Tripepi, G., Dekker, F.W., Zoccali, C., Tanck, M.W. and Jager, K.J., 2010. Sample size calculations: Basic principles and common pitfalls. Nephrology Dialysis Transplantation, 25(10), pp.1388–1393.
[83] Oliveira, S., Andrade, H. and Vaz, T., 2011. The cooling effect of green spaces as a contribution to the mitigation of urban heat: A case study in Lisbon. Building and Environment, 46(11), pp.2186–2194.
[84] Omair, A., 2014. Sample size estimation and sampling techniques for selecting a representative sample. Journal of Health Specialties, 2(4), pp.142–147.
[85] Önder, S. and Akay, A., 2015. Reduction of Traffic Noise Pollution Effects by Using Vegetation, Turkey' Sample. Journal of Engineering and Economic Development, 2(2), pp.23–35.
[86] Ozdemir, B., Bayramoglu, E. and Demirel, O., 2014. Noise pollution and human health in trabzon parks. Studies on Ethno-Medicine, 8(2), pp.127–134.
[87] Panulin, P., n.d. Climate Responsive Design for Damayang Lagi Site. pp.1–15.
[88] Parveen, H. and Showkat, N., 2017. Data Collection. Media & Communication Studies.
[89] Pérez-Lombard, L., Ortiz, J. and Pout, C., 2008. A review on buildings energy consumption information. Energy and Buildings, 40(3), pp.394–398.
[90] Rahman, M.M. and Rahman, H.Y., 2011. Performance of Newly Developed Integrated Space Conditioning and Domestic Water Heating Device. Journal of Energy & Environment, 3(1), pp.23–27.

[91] Rajapaksha, I., Nagai, H. and Okumiya, M., 2002. Indoor Airflow Behavior and Thermal Comfort in a Courtyard House in Warm Humid Tropics. Indoor Air 2002, pp.1072–1077.
[92] Rajapaksha, I., Nagai, H. and Okumiya, M., 2003. A ventilated courtyard as a passive cooling strategy in the warm humid tropics. Renewable Energy, 28(11), pp.1755–1778.
[93]
[94] Ralte, L., Ralte, L., Lalramnghinglova, H. and Et, 2013. Assessment on different levels of noise pollution in Aizawl City, Mizoram, India. Science Vision, 13, pp.157–161.
[95] Reinhart C.F et al : ‚Energy Efficient Solar Buildings’, Position Paper of EUREC published by James and James Science Publishers, London, UK, 2001
[96] Romm, J. and Browning, W.D., 1994. Greening the Building and the Bottom Line Increasing Productivity Through Energy-Efficient Design. Rocky Mountain Institute, pp.1–16.
[97] Roslan, Q., Affandi, R., Ibrahim, S.H., Baharun, A. and Mohd Nawi, M.N., 2016. A literature review on the improvement strategies of passive design for the roofing system of the modern house in a hot and humid climate region. Frontiers of Architectural Research, 5(1), pp.126–133.
[98] Salameh, M. and Taleb, H., 2017. Courtyard as Passive Design Solution for School Buildings in Hot Area. Proceedings of the 2nd World Congress on Civil, Structural, and Environmental Engineering, pp.1–10.
[99] Samuel, D.G.L., Nagendra, S.M.S. and Maiya, M.P., 2013. Passive Alternatives To Mechanical Air Conditioning Of Building: A Review. Building and Environment, 66, pp.54–64.
[100] Santamouris, M., 2005. Passive cooling of buildings. Advances of Solar Energy, University of Athens.
[101] Santamouris, M. and Kolokotsa, D., 2013. Passive cooling dissipation techniques for buildings and other structures: The state of the art. Energy and Buildings, 57, pp.74–94.
[102] Santamouris, M., Pavlou, C., Syneffa, A. and Niachou, K., 2006. Recent Progress on Passive Cooling Techniques: Advanced Technological Developments to Improve Indoor Environmental Quality in Low Income Households. Group Building Environment Studies, University of Athens.
[103] Sapsford, R. and Jupp, V., 2006. Data Collection and Analysis. SAGE Publications.
[104] Schmidt, D., Maas, A. and Hauser, G., 1999. Experimental and Theoretical Case Study on Cross Ventilation. Nordic Journal of Building Physics, 2, pp.1–19.
[105] Showkat, N. and Parveen, H., 2017. Non-Probability and Probability Sampling. Media & Communication Studies.
[106] Sinaga, A.M.H.P., 2014. Difference Between Qualitative And Quantitative Analysis And How It Should Be Applied In Our Research. Academia, pp.1–7.
[107] Smith, J.C., 1999. Passive Cooling Brings Economic and Environmental Benefits. [online] Available at: <https://www.plantengineering.com/articles/passive-cooling-brings-economic-and-environmental-benefits/> [Accessed 18 Feb. 2019].
[108] South African National Standard, 2011. Energy Efficiency in Buildings. SABS Standards Division, .
[109] Stavrakakis, G.M., Zervas, P.L., Sarimveis, H. and Markatos, N.C., 2010. Development of a computational tool to quantify architectural-design effects on thermal comfort in naturally ventilated rural houses. Building and Environment, 45(1), pp.65–80.
[110] Subramanian, C. V and Divya, M., 2016. Solar Passive Architecture Cooling Techniques. International Research Journal of Engineering and Technology (IRJET), 3(12), pp.1388–1394.
[111] Taherdoost, H., 2016. Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. International Journal of Academic Research in Management (IJARM), 5(2), pp.18–27.
[112] Taleb, H.M., 2014. Using passive cooling strategies to improve thermal performance and reduce energy consumption of residential buildings in U.A.E. buildings. Frontiers of Architectural Research, 3(2), pp.154–165.
[113] Tantasavasdi, C., Srebric, J. and Chen, Q., 2001. Natural ventilation design for houses in Thailand. Energy and Buildings, 33(8), pp.815–824.
[114] Tavakol, M. and Dennick, R., 2011. Making sense of Cronbach's alpha. International Journal of Medical Education, 2, pp.53–55.
[115] Taylor, R., 1990. Interpretation of the Correlation : A Basic Review. Journal of Diagnostic Medical Sonography, 1(6), pp.35–39.
[116] Thomas, R. ed., 2006. Environmental design: an introduction for architects and engineers. Taylor & francis.
[117] Thomas, R. and Garnham, T., 2007. The Environments of Architecture. Taylor & Francis.
[118] Thompson, C.B., 2009. Descriptive Data Analysis. Air Medical Journal, 28(2), pp.56–59.
[119] Venkiteswaran, V.K., Liman, J. and Alkaff, S.A., 2017. Comparative Study of Passive Methods for Reducing Cooling Load. Energy Procedia, 142, pp.2689–2697.
[120]
[121] Vetter, T.R., 2017. Descriptive Statistics: Reporting the Answers to the 5 Basic Questions of Who, What, Why, When, Where, and a Sixth, So What? International Anesthesia Research Society, 125(5), pp.1797–1802.
[122] Wahab, I.A. and Ismail, H., n.d. Natural Ventilation Approach in Designing Urban Tropical House. Universiti Tun Hossein Onn Malaysia.
[123] Walliman, N., 2011. Research Methods: The Basics. Routledge.
[124] Williams, C., 2007. Research methods. Research Methods, 5(3), pp.65–72.
[125] World Health Organization (WHO) (2014) Public Health, Environmental and Social Determinants of Health, Geneva
[126] Yilmaz, K., 2013. Comparison of Quantitative and Qualitative Research Traditions: Epistemological, Theoretical, and Methodological Differences. European Journal of Education, 48(2), pp.311–325.
[127] Younis, F.H.A., 2016. Potential Influence of Country on Indoor Environment. Universiti Tun Hussein Onn Malaysia.
[128] Yuan, L.J., 2002. The traditional Malay house. Indigenous and Traditional Knowledge and Practices, pp.73–97.
[129] Zain, Z.M., Taib, M.N. and Baki, S.M.S., 2007. Hot and humid climate: prospect for thermal comfort in residential building. Desalination, 209(1–3), pp.261–268.
[130] Zaki, W.R.M., Nawawi, A.H. and Sh.Ahmad, S., 2012. Environmental Prospective of Passive Architecture Design Strategies in Terrace Houses. Procedia - Social and Behavioral Sciences, 42, pp.300–310.
[131] Zr, D.L. and Mochtar, S., 2013. Application of Bioclimatic Parameter as Sustainability Approach on Multi-story Building Design in Tropical Area. Procedia Environmental Sciences, 17, pp.822–830.